Activity Title: Listening for Fish

Subject (Focus/Topic): Use of acoustics in fish population studies

Grade Level: 9 -12th

Average Learning Time: 45 minutes

Lesson Summary (Overview/Purpose): Students will analyze echograms.

Overall Concept (Big Idea/Essential Question): How do scientists use acoustical data to find specific types of fish?

Specific Concepts (Key Concepts):

Scientists aboard the NOAA Research Vessel *Oscar Dyson* use acoustics, to locate schools of fish before trawling.

This "fish-finder" technology works when transducers emit a sound wave at a particular frequency and detect the sound wave bouncing back (the echo).

When the sound waves return from a school of fish, the strength of the returning echo helps determine how many fish are at that particular site.

Sound waves bounce or reflect off of fish and other creatures in the sea differently.

These reflections of sound (echoes) are sent to computers which display the information in echograms.

Scientists analyze the echograms to determine the type of species present and how many. Based on these findings, they may decide to trawl for fish.

Focus Questions (Specific Questions):

How does "fish-finder" technology work?

What is an echogram?

How are scientists able to use sound waves to determine fish species and school size?

Objectives/Learning Goals:

Students will be able to explain how "fish-finder" technology works.

Given echograms, students will be able to locate the sea floor bottom and schools of fish.

Students will be able to analyze the species distribution amongst the frequencies and predict the type of fish present.

When presented with an unknown echogram, students will successfully locate the sea floor bottom and schools of fish. After analyzing the unknown echogram. students will predict what type of fish is present.

Background Information: This information is also on the student activity sheets.

Scientists aboard the NOAA Research Vessel *Oscar Dyson* use acoustics, to locate schools of fish before trawling. The Oscar Dyson has powerful, extremely sensitive, carefully calibrated, scientific acoustic instruments or "fish finders" including the five SIMRAD EK60 transducers located on the bottom of the centerboard.

This "fish-finder" technology works when transducers emit a sound wave at a particular frequency and detect the sound wave bouncing back (the echo) at the same frequency. When the sound waves return from a school of fish, the strength of the returning echo helps determine how many fish are at that particular site.

Sound waves bounce or reflect off of fish and other creatures in the sea differently. Most fish reflect sound energy sent from the transducers because of their swim bladders, organs that fish use to stay buoyant in the water column.

These reflections of sound (echoes) are sent to computers which display the information in echograms. The reflections showing up on the computer screen are called backscatter. The backscatter is how we determine how dense the fish are in a particular school. Scientists take the backscatter that we measure from the transducers and divide that by the target strength for an individual and that gives the number of individuals that must be there to produce that amount of backscatter. For example, a hundred fish produce 100x more echo than a single fish. This information can be used to estimate the pollock population in the Gulf of Alaska.

Common Misconceptions/Preconceptions: Use of acoustical technology is not just for finding the sea floor depth.

Materials: pictures of capelin, krill, pollock and Pacific Ocean perch, group role cards, laminated echograms, activity sheets

Technical Requirements: none

Teacher Preparation: I suggest printing out larger echograms in color and have them laminated for reuse in the future. Students should be organized into groups of 4. Each group should have a reader, a spokesperson, a manager and a recorder.

Keywords: echogram, acoustics, backscatter, sound waves, swim bladders

Pre-assessment Strategy/Anticipatory Set: Begin the lesson with a photo showing the expanse of the Gulf of Alaska. Ask students how scientists might determine the population size of various fish species for example the walleye pollock.

Lesson Procedure: The activity follows this lesson plan. It is structured similar to a POGIL (Process Oriented Guided Inquiry Learning) activity. Students work through the activity in groups and at stop signs the class regroups to check for understanding before proceeding.

Assessment and Evaluation: Questions associated with the last model (the Pacific Ocean perch echogram) will be used as the tool of assessment. Students should complete these questions independently. The students will demonstrate that they know how to interpret an echogram by successfully answering the questions.

Standards:

- **Next Generation Science Standards Addressed:**

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

- **Ocean Literacy Principles Addressed:**

Although the ocean is large, it is finite and resources are limited.

The ocean provides food, medicines, and mineral and energy resources. It supports jobs and national economies, serves as a highway for transportation of goods and people, and plays a role in national security.

Over the last 50 years, use of ocean resources has increased significantly; the future sustainability of ocean resources depends on our understanding of those resources and their potential.

New technologies, sensors, and tools are expanding our ability to explore the ocean. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories, and unmanned submersibles.

- **OREGON State Science Standards Addressed:**

H.3S.3 Analyze data and identify uncertainties. Draw a valid conclusion, explain how it is supported by the evidence, and communicate the findings of a scientific investigation.

H.3S.5 Explain how technological problems and advances create a demand for new scientific knowledge and how new knowledge enables the creation of new technologies.

H.2L.2 Explain how ecosystems change in response to disturbances and interactions. Analyze the relationships among biotic and abiotic factors in ecosystems.

Author: Julia Harvey, South Eugene High School, 400 East 19th Ave, Eugene, OR 97401

Creation date: 12/30/2013

Listening for Fish

How do scientists locate fish?

WHY?

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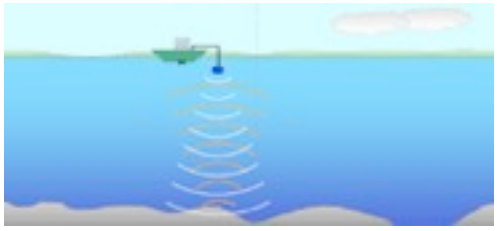

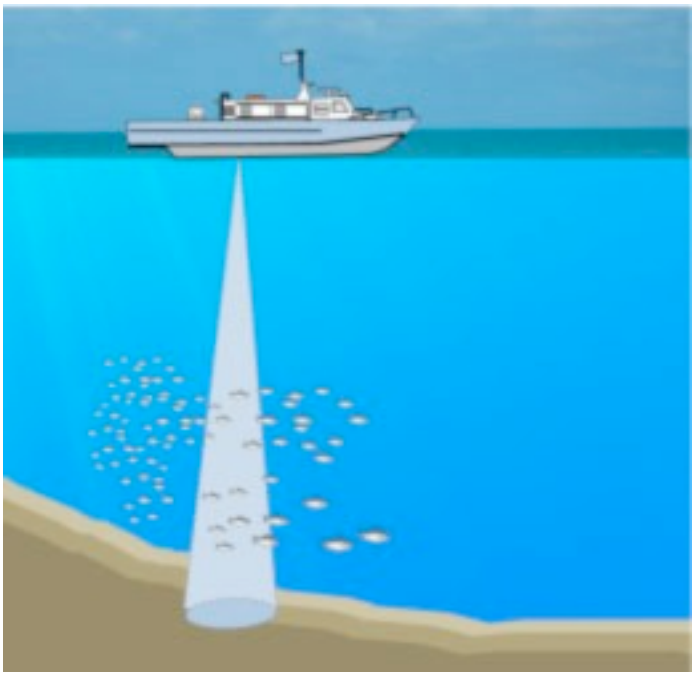

(Images courtesy of biosonicsinc.com)

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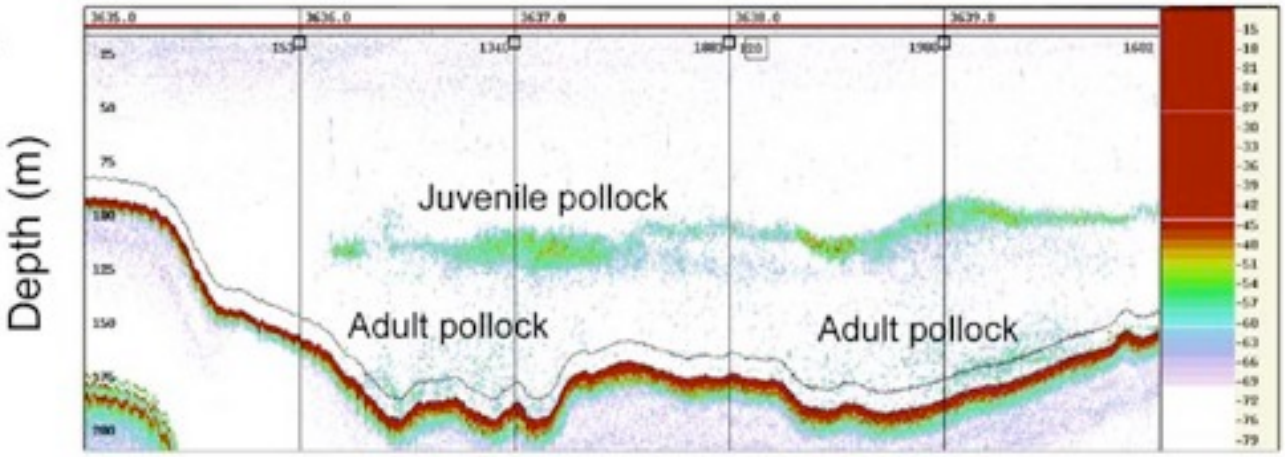
(Echogram images are courtesy of Patrick Ressler of NOAA Alaska Fisheries Science Center)

MODEL 1

A.



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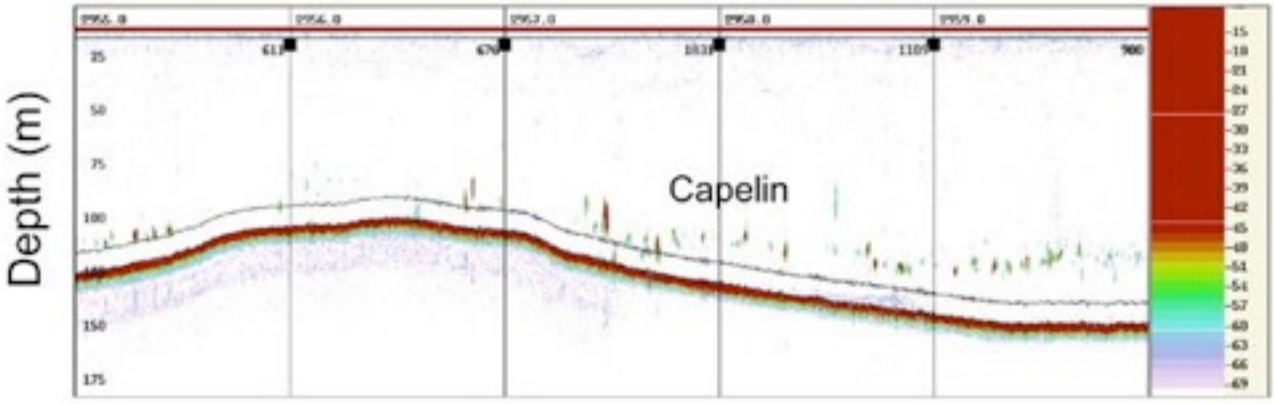


1. Describe model 1?

2. The solid red at the bottom of the picture is the bottom of the sea. What is the greatest depth in B?

3. Describe the sea floor bottom in section A.

4. What is the location difference between adult and juvenile pollock?

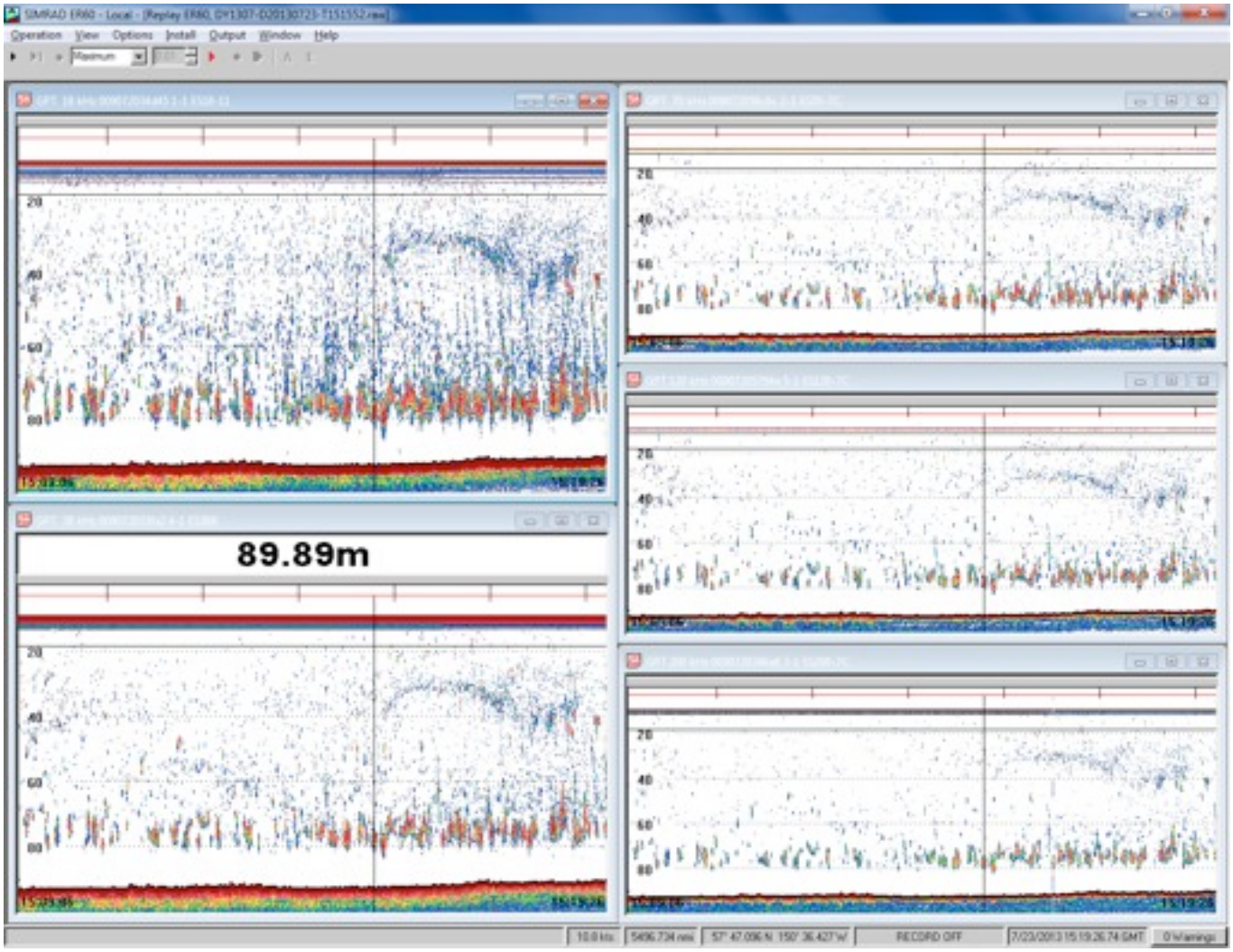
5. How does the capelin distribution differ from juvenile pollock?

Read This!

Aboard the Oscar Dyson, the transducers emit sound waves at various frequencies. These frequencies are 18, 70, 120, 200 and 38 kHz (displayed clockwise from the upper left). Different species of fish produce different backscatter patterns at different frequencies. Scientists can analyze these patterns and determine the fish species present.

Shades of yellow and red show extremely large, dense schools of fish.

MODEL 2

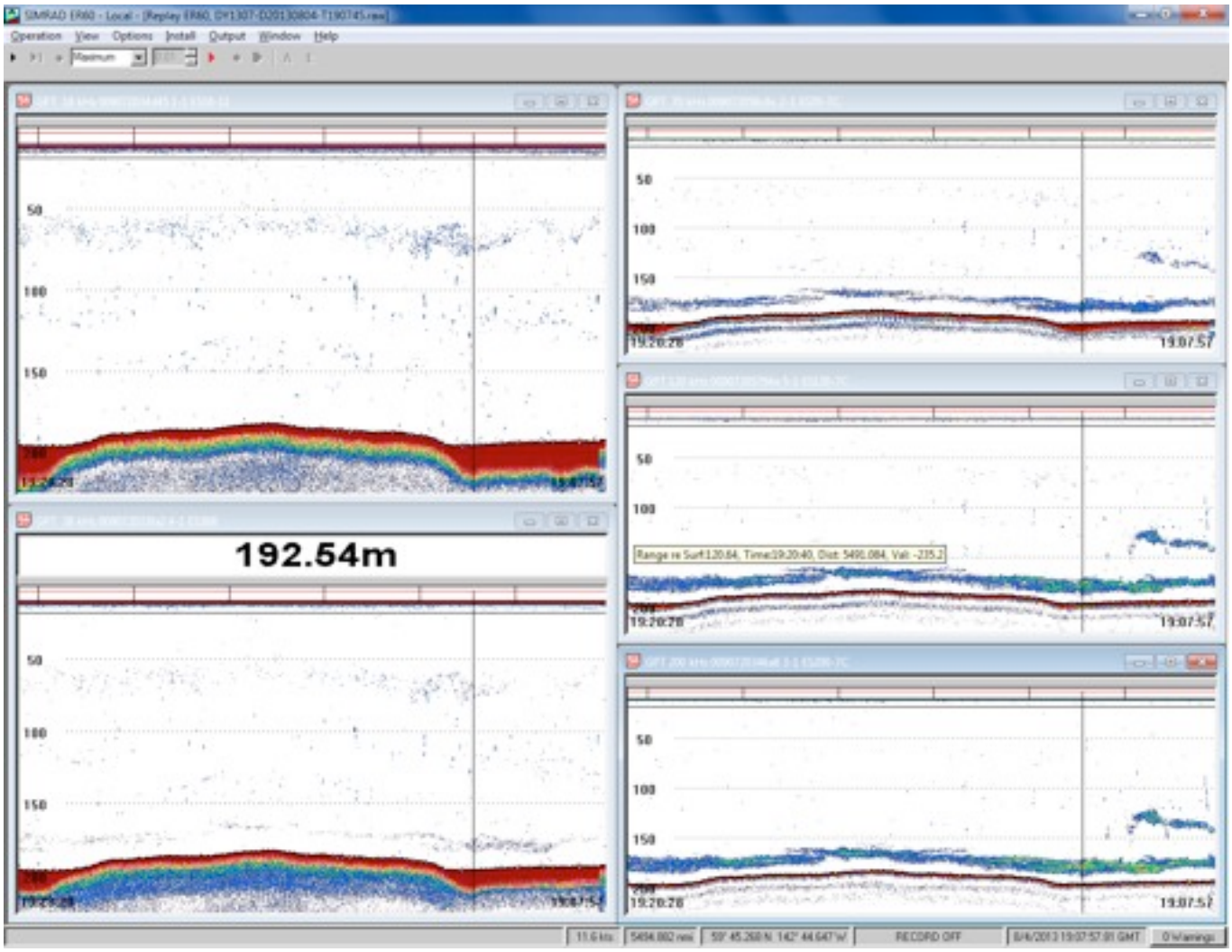


6. How deep is the water in model 2?

7. At what depth are there large schools of fish?

8. How does the backscatter differ at the various frequencies?

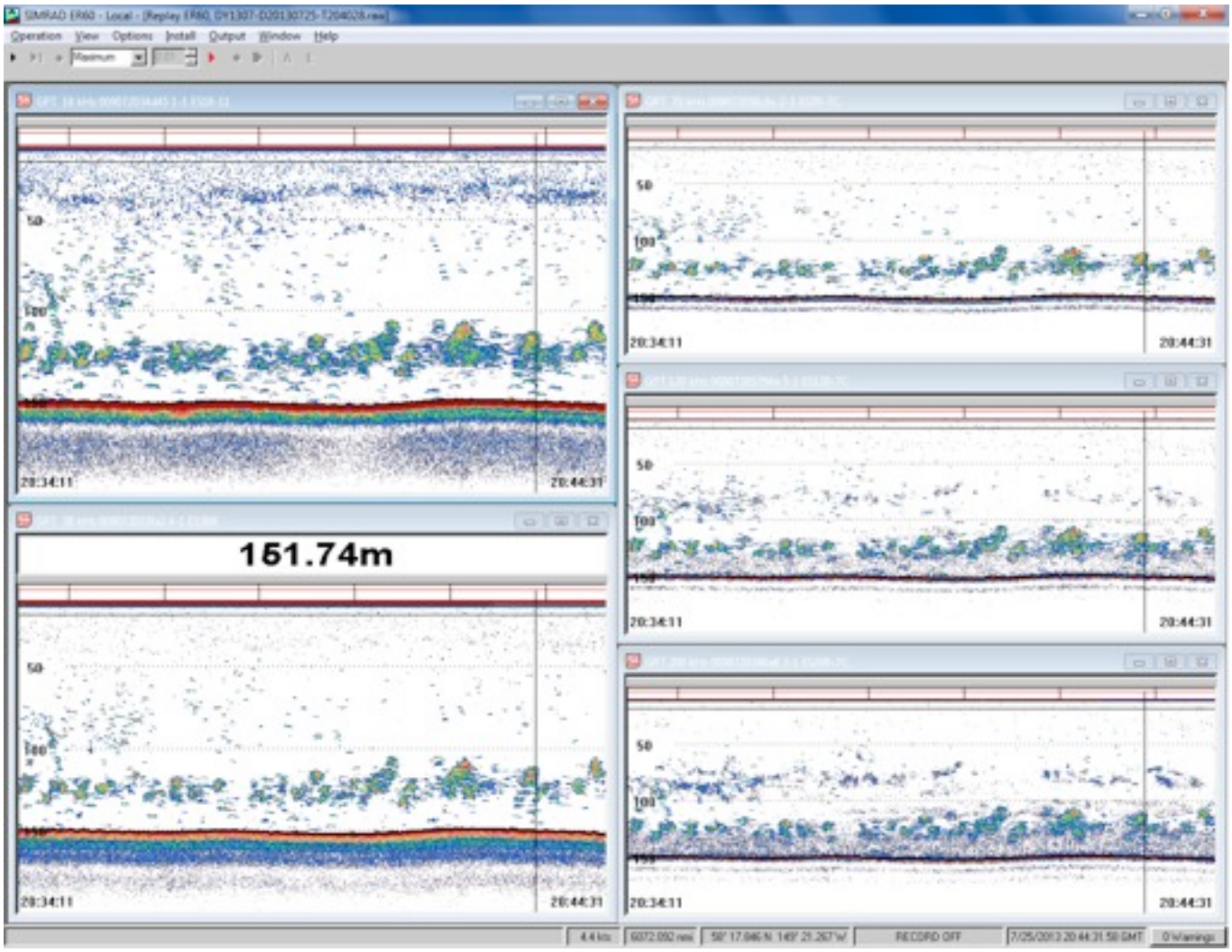
MODEL 3



9. What is the water depth in model 3?

10. Describe the backscatter occurring at a depth of 175m for the various frequencies.

MODEL 4



Read This!

Different species present backscatter patterns that vary at different frequencies. Scientist analyze the acoustic data to determine the type of species present. Krill (Euphausiids) have distinctive backscatter at in the frequencies of 120 and 200 kHz. Pollock, POP, and capelin are all fish whose backscatter is similar at all the of the frequencies used. Sometimes the backscatter looks a little different between these species but the differences are not consistent enough to allow us to sort them out without a trawl sample. All three fish are found from 50 m below the surface to the sea bottom during the daytime. Pollock are the most common and are found throughout the survey area. POP are most often found near the edge of the continental shelf, where the sea bottom is 200 m or deeper. Capelin are more common on shallower banks, at sea bottom depths of less than 100 m.

11. Which model represents krill?

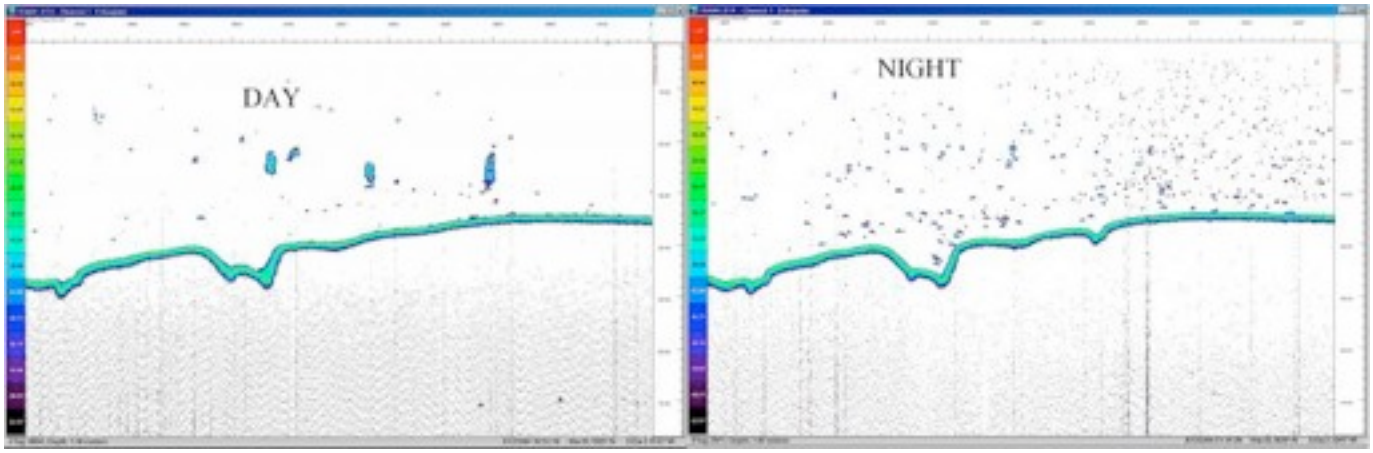
12. Which model represents pollock?

13. Which model represents capelin?

Read This!

During the 2013 Walleye Pollock Survey, fishing generally did not occur after dark. Scientists always noted the time of sunset.

MODEL 5



(image courtesy of http://www.maxdepthaq.com)

14. Looking at the echogram in model 5, suggest a reason for not fishing at night.

Read This!

Scientist monitor the acoustic data and will make a decision on whether or not to fish. Fishing will be done using the Aleutian Wing Trawl (AWT), a mid-water trawl net, the Poly Nor'Eastern (PNE), for bottom trawls or the Methot, which is for gathering samples of very small ocean creatures such as krill.

15. What type of trawl would be used for model 3?

16. What type of trawl would be used for model 4?

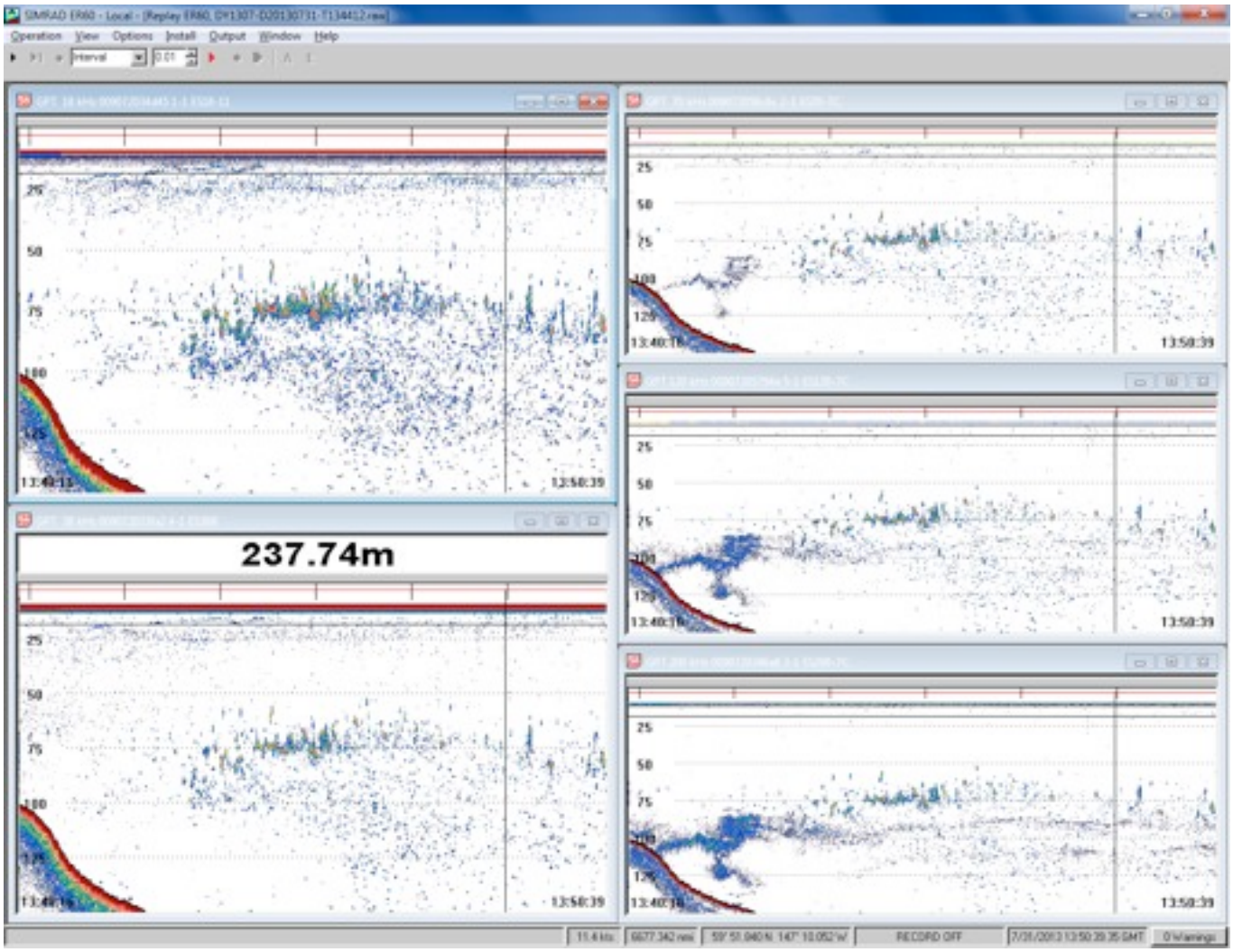
17. It has been decided to trawl based on data in model 4. What depth should they fish at?

Read This!

The trawl data provide a sample from each school and allow the NOAA scientists to take a closer look by age, gender and species distribution. Basically, the trawl data verifies and validates the acoustics data. The acoustics data, combined with the validating biological data from the numerous individual trawls give scientists a very good estimate for the fish populations in this location.

ASSESSMENT

MODEL 6 {This is the back scatter results for Pacific Ocean Perch (POP)}



18. How deep is the water?

19. At what depth are there large schools of fish?

20. At what frequency does the backscatter appear most predominant for these large schools?

21. What species might POP be confused with?

22. What type of net should be used to trawl?

23. What depth should the trawl be lowered to?